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Cellulolytic and pectolytic activity of mycorrhizal fungi, bacteria and actinomycetes associated with the roots of *Pinus sylvestris*[1]

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1. Introduction

It is known that cellulose and pectin are the main components of the cell wall of plants. Enzymes hydrolyzing these compounds are therefore considered to be of importance in plant pathogenesis. They make the penetration of the pathogens through the cell wall possible and enable disintegration of living and dead plant tissues (Goodman *et al.* 1967, Russel 1975, Bateman & Bashan 1976).

The ability of synthesizing cellulolytic and pectolytic enzymes is widespread among plant pathogenic microorganisms (Hussain & Dimond 1960, Capellini & Peterson 1966, Roeb *et al.* 1977, Russel 1975, Mańka 1981). According to Lyr (1963) also most ectomycorrhizal fungi produce cellulases. On the other hand Meyer (1974) and Richards (1974) claim that most ectomycorrhizal fungi do not develop outside the roots of the host plant, because of lack of enzymes hydrolysing cellulose and other complex organic compounds.

Papers on bacteria of forest soils were presented by Jensen (1962, 1963a, b), Bollen (1974), Nioh (1977). Results of extensive studies on bacteria and actinomycetes of forest soils and the root zone of forest trees as well as the achievements of other workers on this subject were published by Szabó (1974).

Little is known however about the enzymatic activity and especially about the cellulolytic and pectolytic activity of bacteria and actinomycetes associated with the roots of forest trees.

It seems, however, that microorganisms accompanying mycorrhizal fungi not only enhance or retard growth of these fungi (Shemakhanova 1967, Vedenyapina 1967, Bowen & Theodorou 1973, 1979) but may also participate in the entrance of the fungus into the root (Voznyakovskaya & Ryzhkova 1955). Our knowledge concerning this problem is scarce. Therefore this research was undertaken.

2. Materials and methods

2.1. Organisms

The following organisms were used in this work: (A) Six isolates of mycorrhizal fungi of pine-*Suillus hirtellus*, *S. luteus*, *S. bovinus*, *Amanita muscaria*, *Rhizopogon luteolus* and Basidiomycetes (No. 2271 — closer not identified). The isolates (except the Basidiomycetes No. 2271) were obtained from the Institute of Dendrology, Polish Academy of Sciences. (B) Twenty bacterial strains (all pleomorphic coryneforms, identical or similar to *Arthrobacter globiformis* — defined in this work as *Arthrobacter* sp.) originating from the rhizosphere and mycorrhizosphere (ten strains from each source respectively) and twelve strains of actinomycetes (all belonging to *Streptomyces sp.*) isolated from root-free soil, rhizosphere and mycorrhizosphere (4 strains from each environment of 13 years old pines). The characteristics of the sites of isolation as well as the methods employed were described previously (Różycki & Strzelczyk 1985).

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[1] This research refers to the Problem II 16, coordinated by the Institute of Dendrology, Polish Academy of Sciences.

2.2. Growth of microorganisms and enzymes assay

2.2.0. Cellulolytic and pectolytic organisms

The fungi were cultured in Saunder's (1948) medium supplemented with either cellulose powder CF 11 (Whatman) or carboxymethylcellulose (CMC, Koch-Light) — 10.0 g/l^{-1} (cellulolytic organisms) or with the same amount of apple pectin (Pektowin-Jasło, Poland) — pectolytic organisms.

The bacteria were grown in the medium of BERG & PETTERSON (1971) and the actinomycetes in that of SHIRLING & GOTTLIEB (1966) supplemented with cellulose powder or CMC or apple pectin.

Fifty ml portions of such media were distributed into 300 ml Erlenmeyer flasks and sterilized at 117 °C for 20 min. The flasks were subsequently seeded with 1 ml of spore suspension of the fungi or bacterial or actinomycete suspension obtained by washing off with 5 cm^3 of sterile water 7 days old slant cultures. After 10 days of incubation at 23 °C (fungi) or 26 °C (bacteria and actinomycetes) the organisms were harvested by centrifugation (5,000 × g) at 4 °C. In the supernatants thus obtained the protein content as well as activity of the exo- and endo-glucanase as well as exo- and endo-polygalacturonase (PG) were determined.

2.2.1. Exoglucanase and exopolygalacturonase (exo-PG) activity

Ten ml of the supernatant liquid were combined with 10 ml of 0.2 M acetate buffer (*p*H 5.5) in fungi, or 0.2 M phosphate buffer (*p*H 7.0) in bacteria and actinomycetes and 10 ml of swollen cellulose (1 mg/ml^{-1}) prepared according to TANSEY (1971). The pectolytic activity was studied in the presence of 10 ml of 1 % solution of apple pectin.

The mixtures were kept during 1 hour in a water bath at 37 °C. Then each received 1 ml of 1 % $ZnSO_4$ and 1 ml of 0.06 n $Ba(OH)_2$ in order to precipitate the protein fraction. Thereafter such mixtures were centrifuged at 7,000 × g min^{-1} and their cellulolytic and pectolytic activity was determined.

The reducing sugars in the supernatants were detected colorimetrically using the method of NELSON & SAMOGYI (1944). Measurements were made in the photocolorimeter "Specol" (Carl Zeiss, Jena) at wavelength 625 nm. The amount of reducing sugars released was calculated from the equation:

$$C(\mu g\ ml^{-1}) = K \times E\ \frac{1\ ml}{625\ nm}$$

where: C — amount of reducing sugars
K — calibration coefficient (86.4 for glucose, 127.8 for galacturonic acid)
E — extinction value.

Calibration curves for glucose and galacturonic acid were made at concentration range 10—200 μg ml^{-1}. As exoglucanase activity unit was assumed the amount of enzyme which in the experimental conditions released 1 μg of glucose per hour per mg of protein.

As specific exo-PG activity unit the amount of enzyme which released 1 μg of galacturonic acid per hour per mg of enzymatic protein was assumed.

2.2.2. Endoglucanase and endopolygalacturonase (endo-PG) activity

Determination of endoglucanase activity was made viscosimetrically by the method of HORTON & KEEN (1966).

Into 9 ml of the supernatant 6 ml of 0.2 M acetate buffer (*p*H 5.5) and 30 ml of 2 % solution of CMC were poured. The mixtures were incubated in the Hoeppler's viscosimeter at 37 °C. The viscosity decrease was measured after 0, 5, 10 and 15 min. of incubation. This method was applied for the fungal and bacterial post culture fluids. The supernatants of actinomycetes were tested in the Oswald-Fenske viscosimeter. The viscosimeters containing 5 ml of 0.2 M phosphate buffer (*p*H 7.0) and 15 ml of 0.1 % of CMC solution were kept for 15 min. in water bath at 37 °C for temperature equilibration. Thereafter 10 ml aliquots of the supernatants were poured into the viscosimeters. The decrease of viscosity was measured after 0, 5, 10 and 15 min. The endo-PG activity in all organisms was studied with the Oswald-Fenske viscosimeter in the presence of 2 % apple pectin.

The endoglucanase and endo-PG activity was calculated according to OSMUNDSVÖG & GOKSÖYR (1975).

The results were given as total and specific activity. The specific units were calculated from equation:

$$\text{Activity (unit/min.)} = \left[\frac{\frac{1}{x} - \frac{1}{0}}{t}\right] \times 1000$$

where: x — viscosity of the sample after 15 min.
0 — viscosity of the blank (immediately after mixing)
t — incubation time in min.

As specific endoglucanase and endo-PG activity unit the amount of enzyme which in the experimental conditions caused a reciprocal change of viscosity $\left[\frac{1}{x}-\frac{1}{0}\right]$ of 0.001 per min. per mg protein was assumed.

2.3. Determination of proteins

Proteins were determined according to Lowry (1951) with bovine albumin (BDH) as a standard.

3. Results

The results of our studies are shown in Tables 1—5. Table 1 presents data on cellulolytic activity of the mycorrhizal fungi. It appears from this table that two of the six fungi studied *(Suillus hirtellus* and *S. bovinus)* produced both cellulolytic enzymes (exo- and endoglucanase) This was noted in media with both CMC and cellulose powder. *Amanita muscaria* produced the two enzymes only in the presence of cellulose powder. In media with CMC it produced only endoglucanase. *Suillus luteus* synthesized endoglucanase in media with CMC and powdered cellulose. The Basidiomycetes No 2271 produced this enzyme only with cellulose powder. *Rhizopogon luteolus* did not produce cellulolytic enzymes at all. In general cellulose powder was a better source of cellulose for endoglucanase production than CMC in the fungi studied.

The results of studies on cellulolytic activity of bacteria are demonstrated in Tab. 2. From among the 10 strains isolated from the rhizosphere only two were cellulolytic. Also only three strains from among 10 originating from the mycorrhizosphere exhibited such activity in the presence of both sources of cellulose. The cellulolytic activity of the bacteria derived from both sources of isolation was however low.

The results of studies on cellulolytic activity of the actinomycetes are shown in Tab. 3. From among the 12 strains studied (four from each rhizosphere, mycorrhizosphere and soil) six showed no cellulolytic activity. None produced exo-glucanase in media with cellulose powder. Only one strain synthesized exoglucanase in media with CMC. Almost all the actinomycetes studied produced endoglucanase in media with CMC. However their activity was low.

Tab. 4 presents the pectolytic activity of the mycorrhizal fungi. It appears from this table that none of these fungi produced endo-PG. *Amanita muscaria* and *Rhizopogon luteolus* did not synthesize pectolytic enzymes at all. The remaining fungi showed different exo-PG activity.

In the post culture liquids of actinomycetes grown with pectin more often endo- than exo-PG were noted (Tab. 5). Endo-PG was found in 6 from among 12 the strains used in this study. Exo-PG activity was noted only in two strains. The pectolytic activity of the actinomycetes was different but in general it was weak.

No bacterial strain used in this work has shown pectolytic activity.

4. Discussion

The entrance of microorganism sinto the root requires secretion of cellulolytic and pectolytic enzymes which hydrolyse the main components of the cell wall (Hussain 1958, Wood 1960, Hussain & Dimond 1960, Russel 1975, Bateman & Bashan 1976). However authors are not unanimous in their opinion on cellulolytic and pectolytic activity im mycorrhizal fungi (Lyr 1963, Meyer 1974, Richards 1974). In spite of the statement of Harley (1948) and Meyer (1974) that mycorrhizal studies should be done in conjunction with rhizosphere studies, this suggestion with few exceptions has not been heeded (Davey 1971). Studies on cellulolytic and pectolytic activity of microorganisms associated with mycorrhizae are an example. It seems that enzymes produced by microorganisms accompanying mycorrhizal fungi could be of importance in the plant — mycorrhizal fungus interrelationship. It was found by Mosse (1962) that the vesicular — arbuscular fungus *Endogone* sp. requires for

Table 1. Cellulolytic activity of mycorrhizal fungi

Mycorrhizal fungi	Kind of cellulose									
	CMC					Cellulose powder				
	Exoglucanase		Endoglucanase		Protein content (mg · 50 cm^{-3})	Exoglucanase		Endoglucanase		Protein content (mg · 50 cm^{-3})
	Total activity^{1})	Specific activity^{2})	Total activity^{3})	Specific activity^{4})		Total activity^{1})	Specific activity^{2})	Total activity^{3})	Specific activity^{4})	
Amanita muscaria	0	0	1.98	0.60	3.3	498.96	262.61	2.77	1.46	1.9
Suillus hirtellus	505.41	174.28	2.96	1.02	2.9	563.70	245.09	4.44	1.93	2.3
Suillus luteus	0	0	3.33	1.51	2.2	0	0	4.44	2.96	1.5
Suillus bovinus	382.35	141.61	4.65	1.72	2.7	531.36	212.54	6.91	2.76	2.5
Rhizopogon luteolus	0	0	0	0	0	0	0	0	0	0
Basidiomycetes Gen. sp. (No. 2271)	0	0	0	0	0	0	0	4.07	2.54	1.6

^{1}) units/hour/50 cm^{3}; ^{2}) units/hour/mg of protein; ^{3}) units min. 50 cm^{-3}; ^{4}) units/min/mg of protein.

Table 2. Cellulolytic activity of bacteria*)

Bacteria	Kind of cellulose									
	CMC					Cellulose powder				
	Exoglucanase		Endoglucanase		Protein content (mg · 10^{-3} cm)	Exoglucanase		Endoglucanase		Protein content (mg · 50 cm^{-3})
	Total activity	Specific activity	Tosal activity	Specific activity		Total activity	Specific activity	Tosal activity	Specific activity	
Arthrobacter sp. No. 5 (R)	0	0	2.96	1.74	1.7	0	0	4 07	2.14	1.9
Arthrobacter sp. No. 37 (R)	0	0	2.20	1.83	1.2	0	0	2.97	1.86	1.6
Arthrobacter sp. No. 3 (M)	0	0	5.56	3.97	1.4	0	0	6.67	4.17	1.6
Arthrobacter sp. No. 20 (M)	0	0	6.30	5.25	1.2	0	0	8.89	5.56	1.16
Arthrobacter sp. No. 24 (M)	0	0	4.07	2.26	1.8	0	0	7.78	4.09	1.9

Remarks: as in Table 1; R — rhizosphere, M — mycorrhizosphere; *) 20 strains of bacteria were used, 15 did not exhibit cellulolytic activity.

Table 3. Cellulolytic activity of actinomycetes*)

Actinomycetes	Kind of cellulose									
	CMC					Cellulose powder				
	Exoglucanase		Endoglucanase		Protein content (mg · 50 cm^{-3})	Exoglucanase		Endoglucanase		Protein content (mg · 50 cm^{-3})
	Total activity	Specific activity	Total activity	Specific activity		Total activity	Specific activity	Total activity	Specific activity	
Streptomyces sp. No. 53 (R)	0	0	0.64	0.22	2.9	0	0	0	0	0
Streptomyces sp. No. 4 (R)	0	0	0.50	0.27	1.9	0	0	1.23	0.55	2.2
Streptomyces sp. No. 32 (R)	0	0	1.71	0.64	2.7	0	0	0.62	0.12	5.2
Streptomyces sp. No. 27 (M)	505.44	102.11	0	0	4.9	0	0	0	0	0
Streptomyces sp. No. 54 (M)	0	0	4.01	2.36	1.7	0	0	0	0	0
Streptomyces sp. No. 7 (M)	0	0	0.80	0.54	1.5	0	0	0	0	0

Remarks as in Tab. 1; R — rhizosphere, M — mycorrhizosphere; *) 12 streptomycete strains were used, 6 did not exhibit cellulolytic activity

Table 4. Pectolytic activity of mycorrhizal fungi*)

Mycorrhizal fungi	Exo-PG		Protein content (mg · 50 cm^{-3})
	Total activity	Specific activity	
Amanita muscarina	0	0	0
Suillus hirtellus	738.05	461.28	1.6
Suillus luteus	2,626.31	570.94	4.6
Suillus bovinus	699.71	279.88	2.5
Rhizopogon luteolus	0	0	0
Basidiomycetes *Cren.* spec. (No. 2271)	1,456.92	323.76	4.5

Remarks: as in Tab. 1; *) the fungi did not exhibit Endo-PG activity.

Table 5. Pectolytic activity of actinomycetes*)

Actinomycetes	Exo-PG		Protein content (mg · 50 cm^{-3})	Endo-PG	
	Total activity	Specific activity		Total activity	Specific activity
Streptomyces sp. No. 22 (S)	696.38	110.89	6.3	0.14	0.02
Streptomyces sp. No. 21 (S)	0	0	3.4	0.41	0.12
Streptomyces sp. No. 53 (R)	0	0	5.4	0.46	0.09
Streptomyces sp. No. 32 (R)	0	0	6.1	0.18	0.03
Streptomyces sp. No. 54 (M)	0	0	4.3	0.52	0.12
Streptomyces sp. No. 15 (M)	0	0	5.6	0.16	0.03
Streptomyces sp. No. 27 (M)	517.59	108.97	4.8	0	0

Remarks: as in Table 1; S — soil, R — rhizosphere, M — mycorrhizosphere; * 12 streptomycete strains were used, 5 did not exhibit pectolytic activity.

entrance into the plant the presence of pectinase or post culture liquids of bacteria producing this enzyme. The above fungus did not produce pectolytic enzymes. VOZNYAKOVSKAYA & RYZHKOVA (1955) found no pectolytic activity in pure cultures of several mycorrhizal fungi, but found abundant pectolytic and cellulolytic bacteria associated with mycorrhizae. According to these authors the bacteria separate the root cortex cells so that the mycorrhizal fungus can enter the root.

Our studies have shown that some mycorrhizal fungi were capable of producing exo- and endo-glucanase in media with CMC or powdered cellulose. *Rhizopogon luteolus* did not produce cellulolytic enzymes at all. This activity was however in general low in all the fungi studied. Little is known about the activity of cellulolytic enzymes in microorganisms associated with mycorrhizae.

The results of our studies on mycorrhizal fungi are in agreement with the data published by other workers who found that not all mycorrhizal fungi exhibit cellulolytic activity (RAWALD 1962, LYR 1963, RITTER 1964). Even less information exists on the production of pectolytic enzymes in mycorrhizal fungi and their role in mycorrhizal establishment.

Microbial metabolites are known to affect growth and enzymatic activity of mycorrhizal fungi and plants (BATEMAN & BASHAN 1976, HACSKAYLO 1971, SLANKIS 1971, DAVEY 1971).

Numerous microorganisms inhabiting the root zone of pine were found to produce such substances. However still little is known about the effect of the associated microorganisms and their metabolites on mycorrhizae formation. Therefore studies on the direct enzymatic action of the root zone microorganisms as well as on the role of their metabolites on the establishment of mycorrhizae are required.

5. References

Bateman, D. F., & H. G. Bashan, 1976. Degradation of plant cell walls and membranes by mycorrhizal enzymes. In: Heitefuss, R., & P. H. Williams (Eds.) Physiological plant pathology. Encyclopedia of plant pathology, Vol. 4. Springer Verlag, Berlin-Heidelberg-New York, 216 to 345.

Berg, B., & G. Petterson, 1971. Growth and cellulase formation by *Cellvibrio fulvus*. J. Appl. Bact., **35**, 201—214.

Bollen, W. B., 1974. Soil microbes. In: Environmental effects of forest residues management in the Pacific Northwest, a State-of-knowledge compendium. USDA Forest Serv. Gen. Techn. Rep. PNW — 24. Pac. Nortwest Forest Range Exp. Stn., Portland, Oregon.

Bowen, G. D., & Theodorou, 1973. Growth of ectomycorrhizal fungi around seeds and roots. In: Marks, G. C., & T. T. Kozlowski (Eds.) Ectomycorrhizae. Acad. Press New York, 107—145.

— — 1979. Interactions between bacteria and ectomycorrhizal fungi. Soil. Biol. Biochem. **11**, 119—126.

Capellini, R. A., & J. L. Peterson, 1966. Production in vitro of certain pectolytic and cellulolytic enzymes by fungi associated with corn stalk root. Bull. Torrey Bot. Club. **93** (1), 52—58.

Davey, C. B., 1971. Non-pathogenic organisms associated with mycorrhizae. In: E. Hacskaylo (ed.), Mycorrhizae. USDA Forest Serv. Misc. Publ., 1189, 114. US Govt. Printing Office, Washington, D.C.

Goodman, R. N., Z. Kiraly & M. Zaitlin, 1967. Biochemistry and physiology of infections plant diseases. D. van Nostrand Comp. Inc. Princeton, New Jersey.

Hacskaylo, E., 1971. Metabolite exchanges in ectomycorrhizae. In: E. Hacskaylo (ed.), Mycorrhizae. USDA Forest Serv. Misc. Publ. 1189, 175. US Govt. Printing Office, Washington, D.C.

Horton, J. C., & T. Keen, 1966. Regulation of induced cellulase synthesis in *Pyrenochaeta terrestris* Gorenz et al. by utilizable carbon compounds. Can. J. Microb. **12**, 209—219.

Hussain, A., 1958. The role of pectic and cellulolytic enzymes in pathogenesis by *Pseudomonas solanacearum*. Phytopathol. **48**, 377.

Hussain, A., & A. E. Dimond, 1960. Role of cellulolytic enzymes in pathogenesis by *Fusarium oxysporum* f. sp. *lycopersici*. Phytopathol. **50**, 329—335.

Jensen, V., 1962. Studies on the microflora of Danish beech forest soils. I. The dilution plate count technique for the enumeration of bacteria and fungi in soil. Zbl. Bakt. (II) **116**, 13—22.

— 1963a. Studies on the microflora of Danish beech forest soils. II. Numbers of microorganisms as determinated by plate counts. Zbl. Bakt. (II) **116**, 348—371.

— 1963b. Studies on the microflora of Danish beech forest soils. III. Properties and composition of the bacterial flora. Zbl. Bacteriol. (II), **116**, 593—611.

Levisohn, I., 1957. Antagonistic effects of *Alternaria tenuis* on certain root-fungi of forest trees. Nature, **179**, 1143.

Lowry, O., N. Rosenbrough, A. Farr and R. Randall, 1951. Protein measurement with the Folin phenol reagent. J. Bill. Chem. **193**, 265.

Lyr, H., 1963. Zur Frage des Streuabbaues durch ektotrophe Mykorrhizapilze. Int. Mykorrhiza-Symposium Weimar, Jena, 123—142.

Mańka, M., 1981. Cellulolytic and pectolytic activity of *Fusarium* isolates pathogenic to corn seedlings. Acta Microbiol. Polon. **1**, 25—32.

Meyer, F. H., 1974. Physiology of mycorrhiza. Ann. Rev. Plant Physiol. **25**, 567.

Mosse, B., 1962. The establishment of vesicular-arbuscular mycorrhiza under aseptic conditions. J. gen. Microbiol. **27**, 59—520.

Nelson, N., 1944. A photometric adaptation of the Samogyi method for determination of glucose. J. Biol. Chem. **153**, 375.

Nioh, I., 1977. Characteristics of bacteria in the forest soil under natural vegetation. Soil Sci. Plant Nutr. **23**, 4, 523.

Osmundsvög, K., & J. Goksöyr, 1975. Cellulase from *Sporocytophaga myxococcoides*. Eur. J. Biochem. **57**, 405—409.

Rawald, W., 1962. Zur Abhängigkeit der Myzelwachstums höheren Pilze von der Versorgung mit Kohlenhydraten. Z. allg. Mikrobiol. **2**, 303—313.

Richards, B. N., 1974. Introduction to the soil ecosystem. Longman Group Limited, Essex.

Ritter, C., 1964. Vergleichende Untersuchungen über die Bildung von Ektoenzymen durch Mycorrhizapilze. Z. allg. Mikrobiol. **4**, 295—312.

Roeb, L., H. Stegeman & E. Langerfeld, 1977. Variation in the activity of polysaccharide and protein degrading enzymes in potato-rotting pathogens of the genus *Fusarium*. Potato Res. **20**, 1, 23—28.

Różycki, H., & E. Strzelczyk, 1985. Synthesis of free amino acids by bacteria isolated from soil, rhizosphere and mycorrhizosphere of pine (*Pinus sylvestris* L.). Zbl. Mikrobiol. **140**, 41—53.

Russel, S., 1975. The role of cellulase produced by *Verticillium* wilt of tomatoes. Phytopath. Z. **82**, 35—48.

Saunders, P. R., R. G. Siu and R. N. Genest, 1948. A cellulolytic enzyme preparation from *Myrothecium verrucaria*. J. Biol. Chem. **174**, 697.

SHEMAKHANOVA, N. M., 1967. [Mycotrophy of woody plants]. Izd. Akad. Nauk SSSR. [Trans. Israel Program Sci. Trans., Jerusalem], 329.

SHIRLING, E. B., & D. GOTTLIEB, 1966. Methods for characterization of *Streptomyces* species. Intern. J. Syst. Bacteriol. **16**, 313—340.

SLANKIS, V., 1961. On the factors determining the establishment ectotrophic mycorrhiza of forest trees. In: Recent Adv. in Bot. Univ. of Toronto Press, Toronto, 1738—1742.

SZABÓ, I. M., 1974. Microbial communities in a forest-rendzina ecosystem. The pattern of microbial communities. Akad. Kadio, Budapest, 415.

TANSEY, M. R., 1971. Agar diffusion assay of cellulolytic ability of termophilic fungi. Arch. Microbiol. **77**, 1—11.

VEDENYAPINA, N. S., 1967. [Effect of *Azotobacter* on the growth of oak seedlings]. Izd. Akad. Nauk SSSR. [Trans. Israel Program Sci. Trans., Jerusalem], 253—259.

VOZNYAKOVSKAYA, I. M., & A. A. RYZHKOVA, 1955. [Microflora accompanying mycorrhizas]. [Trans. Israel Program Sci. Trans., Jerusalem], 320—323.

WOOD, R. K. S., 1960. Pectic and cellulolytic enzyme activity in plant diseases. Ann. Rev. Plant Physiol. **11**, 299—322.

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Cellulolytic and pectolytic activity was studied in mycorrhizal fungi, bacteria and actinomycetes isolated from soil, rhizosphere and mycorrhizosphere of pine. It was found that only two fungi *(Suillus hirtellus* and *S. bovinus)* from among the six studied showed exo- and endo-glucanase activity with powdered cellulose and CMC. Also only 5 bacterial strains (from among 20 studied) were cellulolytic. Almost all the actinomycetes produced endo-glucanase in media with CMC.

None of the mycorrhizal fungi produced endo-PG. More actinomycetes synthesized endo- than exo-PG. No bacterial strain used has shown pectolytic activity.

Key words: Mycorrhizal fungi, bacteria, actinomycetes, cellulolytic, pectolytic, activity.